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54 Tread.  
57 A tire 5 having a plurality of tread layers 10, 12, 14 wherein the outer layers have good cut, wear and tear resistance and the inner layers have good heat resistance. The tire includes a carcass 16 having a crown portion 20, belts 26, sidewalls 18 and circumferential beads 22. A shoulder portion 28 is the area most sensitive to heat buildup.

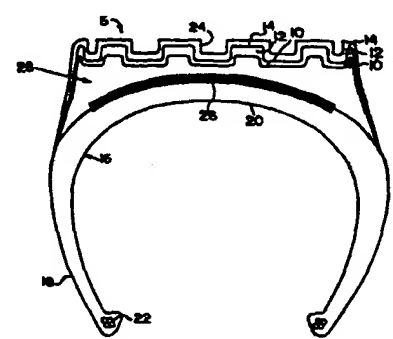


FIG.1

EP 0 105 822 A2

TITLE MODIFIED

see front page

RAINBOW TREADTECHNICAL FIELD

5 This invention relates to tires and, more particularly to a tire having a tread composed of a plurality of layers, each layer having different physical properties.

BACKGROUND ART

10 The conventional method of constructing tires consists of applying and vulcanizing a tread of uniform composition to a tire carcass. Physical properties of the tread compound are dictated by, among other things, the tire load anticipated and the roughness of the terrain in which the tire is used. In many instances, two or more requirements of a tread compound may be inconsistent with each other and thus the tread compound must be a compromise between the competing requirements.

15 20 The shortcomings of prior art tread compositions are especially noticeable in large tires wherein, due to the thickness of the tire, heat tends to build up and is not dissipated from the central portion of the tire, that is the bottom portion of the tread area as well as the belt area. Additionally, the outer tread surface of such a tire in many instances is subjected to abrasion and cutting actions as when utilized in mining operations and the like.

DISCLOSURE OF INVENTION

25 30 It is therefore an aspect of the present invention to provide a tire having inner tread layers of improved heat resistance and outer layers of improved tear resistance.

Another aspect of the invention is to provide a tire having a tread composed of two or more layers, each layer of a different composition, and having a different degree of heat and cut and tear resistance properties.

Another aspect of the present invention is to provide an earth moving tire having a plurality of tread layers, as above, which can be applied by a laminating process.

Still another aspect of the present invention is to provide a tire having a plurality of tread layers, as above, wherein the number of layers ranges from two to ten.

These aspects and others which will become apparent as the detailed description proceeds, are achieved by: a tire, comprising: a carcass; a tread adhered to said carcass; said tread having at least an inner layer having good heat resistant properties; said tread having at least an outer layer having good wear, cut and tear resistant properties; and wherein said tread has from 3 to 10 layers.

In general, a process for making a tire having at least an inner tread layer composition and at least an outer tread layer composition, comprising the steps of: compounding said layer compositions; calendering said layers to a sheet; wrapping said layers on a tire carcass; wherein said inner layer has good heat resistant properties and said outer layer has good wear, cut and tear resistant properties.

#### BRIEF DESCRIPTION OF DRAWINGS

For a complete understanding of the objects, techniques, and structure of the invention, reference should be had to the following detailed description and accompanying drawings wherein:

Fig. 1 is a cross-sectional view of a tire

-3-

having a three layer tread; and

Fig. 2 is a partial cross-sectional view of a tire having a six layer tread.

5      BEST MODE FOR CARRYING OUT THE INVENTION

10      According to the present invention, a tread is provided which has a plurality of layers with the different layers having different physical properties. In general, the outer tread layers will have high abrasion resistance, cutting resistance and the like including good wear rates whereas the inner layers will have good heat resistance.

15      Referring to Fig. 1, a cross-section of a tire having three tread layers is designated by the number 5. Tread layers 10, 12 and 14 are positioned radially outward from a crown portion 20 of a tire carcass 16. Belts 26 may be interposed between layer 10 and crown 20 by suitable means. Carcass 16 also  
20      contains sidewalls 18 and circumferential beads 22 of rigid material on either side.

25      Non-skid tread layer 14 contains tread grooves 24. It can be seen that the tread layers follow tread grooves 24 such that layers 10 and 12 are thinner at the groove locations. Thus, when layer 14 has been worn away, the tire 5 may still contain some tread groove and thus still be serviceable.

30      Layer 14 has extremely good tear and wear resistance properties and relatively poor heat resistance properties. Because a lesser amount of heat is built up on the outer surface of the tread, the lack of heat resistance properties is not detrimental to tire life or to tread 14.

35      On the other hand, a great deal of heat build-up occurs in the shoulder areas 28 and, to a lesser extent in the area immediately above the crown 20 of the carcass 16. It is in the shoulder area 28



-4-

where a great deal of flexing occurs. Heat is generated by hysteretic action and is dissipated very slowly due to the low surface to volume ratio in the shoulder area. Because layer 10 is not in contact with the ground, there is no need to have a high degree of tear, cut and/or wear resistance in this layer, and thus this layer can be optimized for heat resistance. Between layers 10 and 14, layer 12 may be compounded to contain an intermediate amount of heat resistance and tear resistance as it is eventually exposed somewhat to the ground and thus to abrasive rock and particles which may cause tearing. Layer 12 must also resist heat build-up, although to a lesser extent than layer 10.

In Fig. 2, a cross-section of a portion of a six layer tread is designated by the number 30. Layer 34, having good heat resistance properties, is positioned immediately above carcass 32. Above layer 34 are placed sequentially layers 36, 38, 40 and 42 having progressively less heat resistance and progressively more wear, cut and tear resistance. Layer 44 has the greatest amount of wear, cut and tear resistance and relatively poor heat resistance.

As in the three layered embodiment of Fig. 1, a tread groove 46 has several tread layers compressed beneath it. At shoulder area 48, the greatest amount of heat build-up occurs due to flexing of the tread during normal use. Thus, this area has high heat resistance. Heat resistance is measured by rebound, which is an indication of expected heat dissipation efficiency.

There are numerous, well-known and conventional tread compounds yielding good wear, tear and cut resistance which can be utilized in the present invention. Similarly, the same holds true for a tread layer having good heat resistance.

Examples of ingredients which give good

-5-

wear, tear and cut resistance in a tread compound include natural rubber (cis-1,4-polyisoprene), hydrated amorphous silica and equivalents thereof, carbon blacks having either high, intermediate, or low surface areas, common or conventional synthetic rubbers such as styrene-butadiene rubber, synthetic cis-1,4-polyisoprene, and medium vinyl polybutadiene, that is, polybutadiene having a vinyl content of between 30 and 50%. In other words, rubber made from dienes having from 4 to 10 carbon atoms, copolymers made from dienes having from 4 to 10 carbon atoms with vinyl substituted aromatics having from 8 to 12 carbon atoms (e.g., styrene-butadiene rubber), nitrile rubber, and the like. Examples of suitable synthetic rubbers are set forth in The Vanderbilt Rubber Handbook, Winspear, R.T. Vanderbilt Co., 1968, which is hereby fully incorporated by reference. Tread compounds can also be formulated having incorporated therein shredded wire to increase cut resistance.

Tread compounds having good heat resistance generally have a large amount of natural rubber (cis-1,4-polyisoprene) such as Hevea or Guayule, low surface area carbon black, little or no synthetic rubber and little or no amounts of silica or other non-carbon black fillers.

For a three layer tread as in Fig. 1, the wear, cut and tear resistant layer 15 contains between about 0 or 0.1 and 30 PHR of natural cis-1,4-polyisoprene with about between 0 and 10 being preferred; between about 70 and 100 PHR of styrene-butadiene rubber with between about 90 and 100 being preferred; between about 40 and 80 PHR of a high surface area carbon black with between about 55 and 65 PHR being preferred; between about 0 and 30 PHR of a hydrated amorphous silica with about 10 and 20 being preferred. Exemplary of carbon blacks having high surface area and suitable for use in layer 14 are those with the

following ASTM designations: N-121, N-219, N-220, N-231, N-234 and N-242. These blacks are the ones commonly used in tire construction, but it is to be understood that there are other blacks available which are equally suitable but are not normally used in tire compounds because of availability or cost. Furthermore, it is to be understood that whenever a high, intermediate or low surface area carbon black is utilized, either or both of the remaining types of carbon black can be utilized in amounts such that they produce the same type of result as the specified carbon black. In addition, tread layer 14 may have incorporated therein shredded wire of between about 0, or 0.1 and about 20 PHR, said wire having a diameter of between about 0.004 to about 0.008 inches with a length varying between 1/4 and 1/2 inches. The shredded wire is generally steel and optionally may have a brass or copper coating.

Layer 10 having good heat resistance properties can contain about between 70 and 100 PHR of natural cis-1,4-polyisoprene with about between 95 and 100 being preferred; between about 30 and 0 PHR of styrene-butadiene rubber with between about 10 and 0 PHR being preferred; between about 10 and 50 PHR of a carbon black having a low surface area with between about 30 and 40 PHR being preferred; and between about 0 and 15 PHR of a hydrated amorphous silica with between about 5 and 0 being preferred. Carbon blacks having low surface area include those with ASTM designations N-650 and N-660. As previously noted, intermediate or high surface area carbon blacks can also be used in lieu of the low surface area carbon black but is not preferred.

Layer 12, disposed between layers 10 and 14, has intermediate properties, as stated above. A typical formulation for layer 12 includes between about 30 and 75 PHR of natural cis-1,4-polyisoprene, with

betw en about 50 and 70 being pref rred; between about 70 and 25 PHR of styrene-butadiene rubber, with about between 40 and 30 being preferred; between about 25 and 65 PHR of a carbon black having an intermediate surface area with about between 35 and 55 PHR being preferred; and between about 0 and 20 PHR of a hydrated amorphous silica with about between 0 and 10 PHR being preferred. Carbon blacks having intermediate surface area and thus suitable for layer 12 include those with ASTM designations N-326, N-327, N-330, N-339 and N-347.

Each of the three layers 10, 12 and 14 also contain various well known antioxidants, processing oil, curatives, antiozonates, and other conventional additives in amounts which are conventional in the art. Specific examples of these ingredients may be found in The Vanderbilt Rubber Handbook, Winspear, Geo. editor, R.T. Vanderbilt Co., Inc., 1968.

For the six layer tread of Fig. 2, outer, non-skid layer 44 might have the same tread recipe as layer 14 of Fig. 1, thus also high in wear, cut and tear resistance and relatively poor in heat resistance. Further, layer 34 having good heat resistance might have a compounding recipe similar to layer 10 of the tire in Fig. 1. Middle layers 36, 38, 40 and 42 contain tread compounds which have properties intermediate between the innermost and outermost layers 32 and 44 respectively. Generally, the tire compounder has greater flexibility as the number of tread layers is increased. The tread compounds can become more specialized and thus have a narrower range of amounts of ingredients. Thus for example, the outer non-skid layer 44 of the six layer tread might have narrower ranges than the outer layer of the three layer tread. Specifically, th amount of natural rubber or cis-1,4-p lyisoprene is present in the outer lay r in the range of between about 0 and 5 PHR with about between 0 and 3 PHR being preferred. Styrene-butadiene may range in

-9-

between 35 and 45 PHR being preferred; between about 0 and 20 PHR of a hydrated amorphous silica with about 3 and 8 PHR being preferred.

5 Layer 40 would contain about between 40 and 60 PHR of a natural cis-1,4-polyisoprene with about between 48 and 53 PHR being preferred; about between 60 and 40 PHR of styrene-butadiene rubber with about between 48 and 53 PHR being preferred, about between 35 and 55 PHR of an intermediate surface area carbon  
10 black with about between 43 and 48 PHR being preferred and about between 0 and 20 PHR of a hydrated amorphous silica with about between 7 and 13 PHR being preferred. The intermediate surface area carbon blacks of layers 38 and 40 include those having ASTM designations N-326,  
15 N-327, N-330, N-339 and N-347.

Finally, layer 42 positioned just beneath layer 44 would have about between 5 and 40 PHR of a natural cis-1,4-polyisoprene with about between 7 and 13 PHR being preferred; about between 95 and 60 PHR of  
20 styrene-butadiene rubber with about between 93 and 87 PHR being preferred, about between 45 and 65 PHR of a high surface area carbon black with about between 48 and 53 PHR being preferred; about between 0 and 30 PHR of a hydrated amorphous silica with about between  
25 13 and 18 PHR being preferred.

As in the three layer tread 5 of Fig. 1, the six layer tread 30 contains conventional amounts of antioxidants, processing oil and curatives as well as other additives well known to the art. In addition,  
30 any of layers 34 through 44 may contain shredded wire of between 0 and 20 PHR having dimensions similar to those described hereinabove.

While the foregoing describes compositions of the various tread layers of the invention, it will  
35 be appreciated that such disclosure is given to enable those skilled in the art to make tread layers merely representative of those having the desired physical

the amount between about 100 and 95 PHR with between about 100 and 97 being preferred. Carbon black having a high surface area is present in amounts between about 50 and 80 PHR with between about 55 and 65 PHR being preferred. Hydrated amorphous silica is present in amounts between about 0 and 30 PHR with between about 10 and 20 PHR being preferred. Carbon blacks having high surface area and thus suitable for incorporation in the outer layer 44 include those listed above, viz., ASTM designations N-121, N-219, N-220, N-231, N-234 and N-242.

The innermost, heat resistant layer 34 contains between about 95 and 100 PHR of natural cis-1,4-polyisoprene with between about 98 and 100 PHR being preferred; between about 5 and 0 PHR of styrene-butadiene rubber with between about 3 and 9 PHR being preferred; between about 20 and 40 PHR of a low surface area carbon black with between about 25 and 35 PHR being preferred; and between about 0 and 15 PHR of a hydrated amorphous silica with between about 0 and 5 PHR being preferred. Suitable low surface area carbon blacks include ASTM designations N-650 and N-660.

Layer 36 has between about 80 and 95 PHR of a natural cis-1,4-polyisoprene with about between 88 and 92 PHR being preferred; between about 20 and 5 PHR of styrene-butadiene rubber with about between 15 and 8 PHR being preferred; between about 25 and 45 PHR of a low surface area carbon black with about between 37 and 43 PHR being preferred; and about between 0 and 15 PHR of a hydrated amorphous silica with about between 3 and 7 PHR being preferred.

Layer 38 contains about between 60 and 80 PHR of a natural cis-1,4-polyisoprene with about between 73 and 78 PHR being preferred; about between 40 and 20 PHR of styrene-butadiene rubber with about between 30 and 27 PHR being preferred; between about 30 and 50 PHR of an intermediate surface area carbon black with about

-10-

properties. Other compound recipes may be used to make tread layers having the same physical properties. Accordingly, reference should be made to Table II and Table III which summarize the physical properties of a three layered and a six layered tread respectively.

A conventional laminating process used for manufacturing earth moving tires and other large tires lends itself nicely to the use of a plurality of tread layers as described herein. In the laminating process the rubber compound is broken down either on a mill or on a cold feed extruder, then calendered to a sheet and wrapped on the tire carcass to the desired thickness and profile. The wrapping is carried out at between about 150° to about 190°F. The laminating process can also be adapted to smaller tires such as tractor tires, passenger tires and the like. Rubber compounds are fed to the extruder in the order in which they are applied to the tire carcass. Thus, for a six layered tread, the compound of layer 34 is first fed to the extruder, followed by layers 36, 38, 40, 42 and 44. Some blending occurs where the heels of the adjacent compounds mix in the extruder.

The invention will be better understood by reference to the following example. The following example illustrates the preferred embodiment in which a six layered tread is applied to an earth moving tire.

#### EXAMPLE I

The compounds set forth in Table I were charged to an extruder feeding a laminating machine. Compound F was charged first followed sequentially by compounds E, D, C, B, and A. These combinations of rubbers, carbon blacks, etc., are combined with conventional compounding ingredients including sulfur, zinc oxide, stearic acid, and the like. The laminator

-11-

calendered the rubber giving a layer of rubber .080-.090 inches thick which was continuously wrapped on the tire carcass mounted on a conventional drum. Each layer was 1/2 to 1-1/2 inches thick. The tire was then cured in a conventional manner.

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-12-

TABLE I

		Outer Layer High Wear, Tear & Cut Resistance				Inner Layer Best Heat Resistance	
		A	B	C	D	E	F
5	Natural Rubber	0	10	50	75	90	100
	SBR	100	90	50	25	10	0
10	Carbon Black						
	Iodine #115(a)	60	59				
	Iodine # 85(b)			45	40		
	Iodine # 35(c)					40	30
	Hydrated Amorphous						
15	Silica (o)	15	15	10	5	5	0
	Antioxidant (1)	2	2	2	2	2	2
	Processing Oil (2)	25	25	10	10	10	10
	Accelerator (3)	2	2	2	2	2	2
20	300% Modulus	9.1	9.8	10.4	11.4	11.4	11.6
	Tensile (4)	17.7	18.4	19.2	20.0	22.2	24.0
	Elongation (%)	500	510	525	550	555	555
	Tear N/IN	1290	1280	1260	1249	940	890
	Rebound (%) (5)	69	71	73	75	80	89
25	Pico Abrasion (6)	103	98	96	94	82	80

(a) High surface area.

(b) Intermediate surface area.

(c) Low surface area.

30 (o) Hi-Sil 215 manufactured by Pittsburgh Plate Glass

(1) Diamine type.

(2) Aromatic type.

(3) Morpholine disulfide type.

35 (4) Meganewtons per square meter.

(5) Measured by ASTM 1054.

(6) Measured by ASTM D 2228.

TABLE IIPHYSICAL PROPERTIES  
THREE LAYER TREAD

Tread Layer	Range	Tear <sup>1</sup>	Rebound <sup>2</sup>	Pica Abrasion <sup>3</sup>
Inner	General	830-1050	82-96	70-90
	Desired	850-930	85-93	75-85
	Preferred	870-910	87-91	78-82
Middle	General	1050-1290	69-82	84-104
	Desired	1210-1270	71-79	89-99
	Preferred	1230-1250	73-77	92-96
Outer	General	1230-1350	64-74	96-110
	Desired	1250-1330	66-72	98-108
	Preferred	1270-1310	68-70	101-105

1. Measured in Newtons/Inch on Instron

2. ASTM D1054 (Z)

3. ASTM D2228 Units.

-14-

TABLE IIIPHYSICAL PROPERTIES  
SIX LAYER TREAD

5	TREAD LAYER	RANGE	TEAR <sup>1</sup>	REBOUND <sup>2</sup>	PICO ABRASION <sup>3</sup>
	Inner	General	830-1060	82-96	70-90
		Desired	850-930	85-93	75-85
		Preferred	870-910	87-91	78-82
10	2nd Inner	General	1060-1200	75-85	74-94
		Desired	1200-1280	77-83	77-87
		Preferred	1220-1260	79-81	80-84
15	3rd Inner	General	1190-1290	69-81	84-104
		Desired	1210-1270	71-79	89-99
		Preferred	1230-1250	73-77	92-96
	4th Inner	General	1200-1330	67-79	88-108
		Desired	1230-1300	69-77	91-101
		Preferred	1250-1270	71-75	94-98
20	5th Inner	General	1230-1330	65-76	92-110
		Desired	1250-1310	67-74	94-102
		Preferred	1270-1290	69-72	96-100
25	6th Inner	General	1230-1350	64-74	96-112
		Desired	1250-1330	66-72	98-108
		Preferred	1270-1310	68-70	101-105

1. Measured in Newtons/Inch on Instron

2. ASTM D1054 (%)

3. ASTM D2228 Units

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5 In general, the number of tread layers can vary from 2 to about 10, more commonly from 3 and 7 layers, and preferably from 3 to 6. Tread layer thickness depends to a large extent on the type of tire being manufactured and the number of layers desired. Generally the thickness may vary between about 1/4 and 6 inches, desirably between 1 inch and 4 inches. For earth moving tires, about 1-1/2 inches per tread layer is preferred.

10 While in accordance with the Patent Statutes, the best mode and preferred embodiments have been set forth, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit or scope of the invention. Accordingly, the invention is measured by  
15 the scope of the attached claims.

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WHAT IS CLAIMED IS:

1. A tire, characterizing:  
a carcass;  
a tread adhered to said carcass;  
5 said tread having at least an inner layer  
having good heat resistant properties;  
said tread having at least an outer layer  
having good wear, cut and tear resistant properties;
- 10 wherein said tread has from 3 to 10 layers,  
each of said tread layers containing one or more  
ingredients selected from the group consisting of  
natural cis 1,4 polyisoprene, carbon black, synthetic  
rubber, and hydrated amorphous silica; and  
15 wherein said tread layers are between 1/4  
inch and 6 inches in thickness.
2. A tire according to Claim 1, wherein  
said tread has three layers, characterizing:  
20 said inner layer having a tear value of  
from about 830 to 1050 Newtons per inch, a rebound  
value of between about 82% and 96% and a Pico abrasion  
value of from about 70 and 90;  
a middle layer having a tear value of be-  
25 tween about 1050 and 1290 Newtons per inch, a rebound  
value of from about 69% and 82%, and a Pico abrasion  
value of between about 84 and 104; and  
said outer layer having a tear value of  
between about 1230 and 1350 Newtons per inch, a rebound  
30 value of from about 64% and 74%, and a Pico abrasion  
value of from about 96 and 100..
3. A tire according to Claim 1, wherein  
said tread has six layers, comprising:  
35 said inner layer having a tear value of

between about 830 and 1060 Newtons per inch, a rebound value of from about 82 and 96, and a Pico abrasion value of from about 70 and 90;

5 a second innermost layer having a tear value of from about 1060 and 1200 Newtons per inch, a rebound value of from about 75 and 85, and a Pico abrasion value of from about 74 and 94;

10 a third innermost layer having a tear value of from about 1190 and 1290 Newtons per inch, a rebound value of from about 69 and 81 and a Pico abrasion value of from about 84 and 104;

a fourth innermost layer having a tear value of from about 1200 and 1330 Newtons per inch, a rebound value of from about 67 and 79, and a Pico abrasion value of from about 88 and 108;

15 a fifth innermost layer having a tear value of from about 1230 and 1330 Newtons per inch, a rebound value of from about 65 and 76, and a Pico abrasion value of from about 92 and 100; and

20 said outer layer having a tear value of from about 1230 and 1350 Newtons per inch, a rebound value of from about 64 and 74, and a Pico abrasion value of from about 96 and 112.

25 4. A tire according to Claim 1, wherein said tire has 3 layers and said inner layer has between about 70 and 100 PHR of a natural cis 1,4 polyisoprene; about between 30 and 0 PHR of synthetic rubber; between about 10 and 50 PHR of a low surface area carbon black; and between about 0 and 15 PHR of a hydrated amorphous silica;

30 said outer layer has about between 0 and 30 PHR of a natural cis 1,4 polyisoprene; about between 70 and 100 PHR of synthetic rubber; about between 40 and 80 PHR of a high surface area carbon black; and  
35 about between 0 and 30 PHR of a hydrated amorphous

silica; and

wherein said tire has an intermediate layer having between about 30 and 75 PHR of a natural cis 1,4 polyisoprene; about between 70 and 25 PHR of synthetic rubber; about between 25 and 65 PHR of an intermediate surface area carbon black; and about between 0 and 20 PHR of a hydrated amorphous silica.

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5. A tire according to Claim 1, wherein said tread has six layers, said inner layer having between about 95 and 100 PHR of natural cis 1,4 polyisoprene; between about 5 and 0 PHR of synthetic rubber; between about 20 and 40 PHR of a low surface area carbon black; and between about 0 and 15 PHR of a hydrated amorphous silica; and

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said outer layer having between about 0 and 5 PHR of natural cis 1,4 polyisoprene; between about 100 and 95 PHR of synthetic rubber; between about 50 and 70 PHR of a high surface area carbon black; and between about 0 and 30 PHR of a hydrated amorphous silica;

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the second innermost layer having between about 80 and 95 PHR of natural cis 1,4 polyisoprene; between about 20 and 5 PHR of synthetic rubber; between about 25 and 45 PHR of a low surface area carbon black; and between about 0 and 15 PHR of a hydrated amorphous silica;

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the third innermost layer having between about 60 and 80 PHR of natural cis 1,4 polyisoprene; between about 40 and 20 PHR of synthetic rubber; and between about 30 and 50 PHR of an intermediate surface area carbon black; and between about 0 and 20 PHR of a hydrated amorphous silica;

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the fourth innermost layer having between about 40 and 60 PHR of natural cis 1,4 polyisoprene;

between about 60 and 40 PHR of synthetic rubber;  
between about 35 and 55 PHR of an intermediate surface area carbon black; and between about 0 and 20 PHR of a hydrated amorphous silica; and

the fifth innermost layer having between  
about 5 and 40 PHR of natural cis 1,4 polyisoprene;  
between about 95 and 60 PHR of synthetic rubber;  
between about 45 and 65 PHR of a high surface area carbon black; and between about 0 and 30 PHR of a hydrated amorphous silica; and

wherein said tread layers are each about 1/2 inches thick and wherein said tire is an earth moving tire.

6. A process for making a tire having at least an inner tread composition and at least an outer tread layer composition, characterizing the steps of:

compounding said layer compositions;  
calendering said layers to a sheet;  
wrapping said layers on a tire carcass;  
wherein said inner layer has good heat resistant properties and said outer layer has good wear, cut and tear resistant properties;

wherein said tread layers contain one or more ingredients selected from the group consisting of natural cis 1,4 polyisoprene, carbon black, synthetic rubber, and hydrated amorphous silica; and

wherein said tread has between 2 and about 10 layers.

7. A process according to Claim 6, wherein said tire has 3 layers, said inner layer having between about 70 and 100 PHR of a natural cis 1,4 polyisoprene; about between 30 and 0 PHR of synthetic rubber; between about 10 and 50 PHR of a low surface



area carbon black; said outer layer having about between 0 and 30 PHR of a natural cis 1,4 polyisoprene; about between 70 and 100 PHR of a synthetic rubber; about between 40 and 80 PHR of a high surface area carbon black; and about between 0 and 30 PHR of a hydrated amorphous silica; and

wherein said tread has an intermediate layer having from about 30 and 75 PHR of a natural cis 1,4 polyisoprene; about between 70 and 25 PHR of synthetic rubber; about between 25 and 65 PHR of an intermediate surface area carbon black; and about between 0 and 20 PHR of a hydrated amorphous silica.

8. A process according to Claim 6, wherein said tread has six layers, said inner layer having between about 95 and 100 PHR of a natural cis 1, 4 polyisoprene; between about 5 and 0 PHR of synthetic rubber; between about 20 and 40 PHR of a low surface area carbon black; and between about 0 and 15 PHR of a hydrated amorphous silica;

said outer layer has between about 0 and 5 PHR of natural cis 1,4 polyisoprene; between about 100 and 95 PHR of synthetic rubber; between about 50 and 70 PHR of a high surface area carbon black; and between about 0 and 30 PHR of a hydrated amorphous silica.

9. A process according to Claim 8, wherein the second innermost layer has between about 80 and 95 PHR of natural cis 1,4 polyisoprene; between about 20 and 5 PHR of synthetic rubber; between about 25 and 45 PHR of a low surface area carbon black; and between about 0 and 15 PHR of a hydrated amorphous silica;

wherein the third innermost layer has between about 60 and 80 PHR of natural cis 1,4 polyisoprene; between about 40 and 20 PHR of synthetic rubber;

between about 30 and 50 PHR of an intermediate surface area carbon black; and between about 0 and 20 PHR of a hydrated amorphous silica;

wherein said fourth innermost layer has between about 40 and 60 PHR of natural cis 1,4 polyisoprene; between about 60 and 40 PHR of synthetic rubber; between about 35 and 55 PHR of an intermediate surface area carbon black; and between about 0 and 20 PHR of a hydrated amorphous silica;

wherein the fifth innermost layer has between about 5 and 40 PHR of natural cis 1,4 polyisoprene; between about 95 and 60 PHR of synthetic rubber; between about 45 and 65 PHR of a high surface area carbon black; and between about 0 and 30 PHR of a hydrated amorphous silica.

10. A process according to Claim 9, including milling said layer composition, and cold feed extruding said layer composition before calendaring said layer into a sheet;

wherein said tread layers are each about 1 - 1/2 inches thick and said tire is an earth moving tire.

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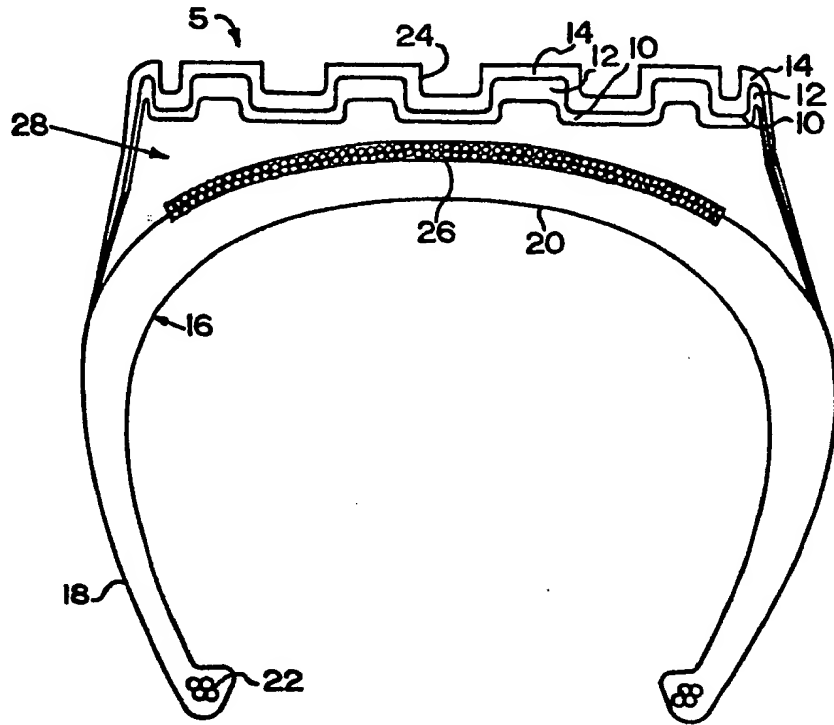
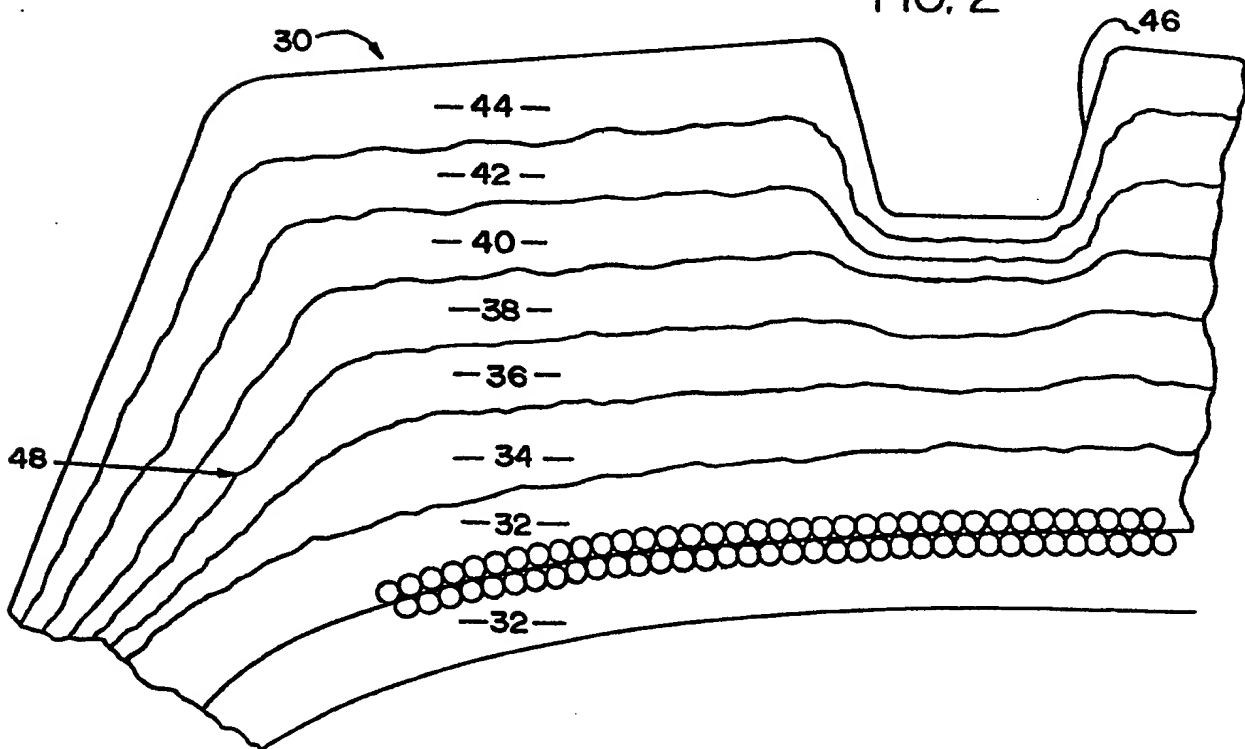


FIG. 1

FIG. 2







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- (56) Prior Art Documents  
US 5174838  
US 4530959  
US 3788537
- (57) Claim

1. A pneumatic tire having a TRA rated load limit of at least about 1220 kg at an inflation pressure in a range of about 723 to about 792 kpa and having a bead diameter of at least about 48 cm is provided having a rubber tread of cap/base construction wherein

(A) said tread cap is comprised of, based on 100 parts by weight rubber, (1) an elastomer composition comprised of (a) about 20 to about 70 phr of at least one medium to high vinyl polybutadiene elastomer having a vinyl 1,2-content in a range of about 35 to about 80 percent and (b) about 30 to about 80 phr cis 1,4-polyisoprene natural rubber, (2) about 40 to about 85 phr of reinforcing filler comprised of (a) about 5 to about 70 weight percent carbon black and, correspondingly, (b) about 95 to about 30 percent precipitated silica and (c) at least one silica coupler having a silan moiety reactive with the surface of the silica and a moiety interactive with said elastomers; and



(11) AU-P-50789/96  
(10) 694334

-2-

(B) said tread base is comprised of, based on 100 parts by weight rubber, (1) 100 parts by weight cis 1,4-polyisoprene natural rubber, (2) about 35 to about 55 phr of reinforcing filler comprised of (a) about 40 to about 85 weight percent carbon black and, correspondingly, about 60 to about 15 weight percent precipitated silica.





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**AUSTRALIA**  
**PATENTS ACT 1990**

**COMPLETE SPECIFICATION**

**FOR A STANDARD PATENT**

**ORIGINAL**

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Invention Title: Tire with Tread of Cap-Base Construction

The following statement is a full description of this invention, including the best method of performing it known to me/us:-



TIRE WITH TREAD OF CAP/BASE CONSTRUCTION

Field

5 This invention relates to a tire having a rubber tread of a cap/base construction wherein the tread base is composed of carbon black and silica reinforced natural rubber and the tread cap is composed of a blend of elastomers which is reinforced with a combination of carbon black and silica.

10 The invention particularly relates to truck tires.

Background

15 Pneumatic rubber tires are conventionally prepared with a rubber tread which can be a blend of various rubbers which is typically reinforced with carbon black.

20 In one aspect, tires such as, for example, truck tires and heavy duty light truck tires, which are normally expected to be capable of supporting and carrying relatively large vehicular loads, tend to generate a greater internal temperature than comparable passenger vehicle-type tires.

25 The truck tire treads are typically of a cap/base construction, with the tread cap designed to be ground-contacting and, thus, contain a lug/groove configuration, and with the tread base underlying and supporting the tread cap and positioned between the tread cap and the tire carcass. The tread base is not  
30 intended to normally be ground-contacting and, thus, not normally intended to have the same measure of tread properties as, for example, the tread cap properties of traction and treadwear.

35 For such relatively heavy duty tires, heat buildup, evidenced by tire running temperature buildup, or increase is normally unwanted, although a



substantial portion of the heat buildup, or temperature increase, is relatively unavoidable during a running of the tire under load.

5 However, it remains to be desirable to provide a rubber tire tread for use with tires on various heavy service vehicles, including light to medium trucks, which generate less heat under typical operational conditions since higher tire running conditions tend to prematurely age the tire rubber and associated tire  
10 construction and, thus, tend to shorten the effective life of the tire.

In another aspect, it is desired to provide such a tire which can generate less heat under operational conditions, yet have acceptable treadwear and traction  
15 (skid resistance).

It is envisioned that such tread would be of a cap/base construction. Tires having treads of cap/base construction, in general, are well known to those skilled in such tire tread art. For example,  
20 see U.S. Patent No. 3,157,218 which is intended to be incorporated herein by reference as being illustrative of such tread construction.

In the practice of this invention, it is envisioned that a cap/base constructed tread is provided in which the tread base is of a natural rubber composition reinforced with carbon black or a combination of carbon black and silica. It is further envisioned that the tread cap be reinforced with carbon black for which at least a portion of the  
25 carbon black reinforcement is replaced with precipitated silica accompanied with a silica coupler.  
30

The purpose of the replacing a portion of the reinforcing carbon black filler with silica is to provide a tread cap which can run cooler, lower the  
35 tire rolling resistance, and also enhance tread traction capabilities, as compared to a comparable



tread cap with an equivalent amount of carbon black reinforcing filler and without the silica. It is contemplated that a silica reinforced rubber tread would experience less temperature buildup than a  
5 comparable carbon black reinforced rubber tread under similar working conditions, namely, as a tire on a vehicle being run under loaded, operational conditions.

However, for many tire tread applications, it is  
10 contemplated that a replacement of a quantitative amount of carbon black by silica in a tire tread may compromise the treadwear aspect of the tire.

In one aspect for tire treads, various rubbers, or elastomers, are evaluated, selected and blended for  
15 a purpose of achieving desired tire tread properties and particularly a balance of tire tread characteristic properties, mainly, rolling resistance, traction and wear.

For various applications utilizing rubber,  
20 including applications such as tires and particularly tire treads, sulfur cured rubber is utilized which contains substantial amounts of reinforcing filler(s). Carbon black is commonly used for such purpose and normally provides or enhances good physical properties  
25 for the sulfur cured rubber. Particulate silica might also sometimes be used for such purpose, particularly if the silica is used in conjunction with a coupling agent. In some cases, a combination of silica and carbon black has been utilized for reinforcing fillers  
30 for various rubber products, including treads for tires.

It is important to appreciate that, conventionally, carbon black is considered to be a more effective reinforcing filler for rubber tire  
35 treads than silica if the silica is used without a coupling agent.





Indeed, at least as compared to carbon black, there tends to be a lack of, or at least an insufficient degree of, physical and/or chemical bonding between the silica particles and the rubber elastomers to enable the silica to become an effective, or efficient, reinforcing filler for the rubber for most purposes, including tire treads, if the silica is used without a coupler. While various treatments and procedures have been devised to overcome such deficiencies, compounds capable of reacting with the silica surface and interacting with the rubber elastomer molecule are desirable. The compound might be generally referred to, by those having skill such art, as coupling agents, or silica couplers or silica adhesives. Such coupling agents, for example, may be premixed, or pre-reacted, with the silica particles or added to the rubber mix during the rubber/silica processing, or mixing, stage. If the coupling agent and silica are added separately to the rubber mix during the rubber/silica mixing, or processing stage, it is considered that the coupling agent then combines in situ with the silica.

In particular, such coupling agents may be composed, for example, of a silane which has a constituent component, or moiety, (the silane portion) capable of reacting with the silica surface and, also, a constituent component, or moiety, capable of interacting with the rubber, particularly a sulfur vulcanizable rubber which contains carbon-to-carbon double bonds, or unsaturation. In this manner, then the coupler acts as a connecting bridge between the silica and the rubber and thereby enhances the rubber reinforcement aspect of the silica.

The rubber-interactive group component, r moiety, of the coupler may be, for example, one or more of groups such as mercapto, amino, vinyl, epoxy,



and sulfur groups, preferably a sulfur or mercapto moiety and more preferably sulfur.

Numerous coupling agents are taught for use in combining silica and rubber such as, for example, 5 silane coupling agents containing a polysulfide component, or structure, such as, for example, bis 3- (trialkoxysilylalkyl) polysulfide where the polysulfide bridge contains from 2 to about 8 10 connecting sulfur atoms. Such a polysulfide might be, for example, bis-3-(triethoxysilylpropyl) tetrasulfide, trisulfide or disulfide (e.g. U.S. Patent No. 3,873,489).

For silica reinforced tire treads, U.S. Patent No. 5,227,425 discloses the use of a solution 15 polymerization prepared SBR which is silica reinforced with a filler of silica and carbon black which contains at least 30 weight percent silica with specified silica characterizations and in which is 20 preferenced over an emulsion polymerization prepared SBR. U.S. Patent No. 4,519,430 discloses a silica rich tire tread which contains solution or emulsion SBR, optionally with polybutadiene rubber and/or polyisoprene rubber together with a mixture of silica and carbon black, with silica being required to be a 25 major component of the silica/carbon black reinforcing filler.

The term "phr" where used herein, and according to conventional practice, refers to parts of a 30 respective material per 100 parts by weight or rubber, or elastomer.

In the description of this invention, the terms "rubber" and "elastomer", where used herein unless otherwise prescribed, are used interchangeably. The terms "rubber composition", "compounded rubber" and 35 "rubber compound" where used herein unless otherwise prescribed, are used interchangeably to refer to



rubber which has been blended or mixed with various ingredients or materials and such terms are well known to those having skill in the rubber mixing, or rubber compounding, art.

5       The Tg of a polymer, particularly an elastomer, as used herein unless other wise prescribed, refers to its glass transition temperature which can conventionally be determined, for example, by a differential scanning calorimeter at a heating rate  
10 of, for example, about 10°C to 15°C, to an observed transition of the temperature versus time curve. It is understood that such Tg determination is well known to those having skill in such art.

15   Summary and Practice of the Invention

      In accordance with this invention, a pneumatic tire having a TRA maximum rated load limit of at least about 1220 kg, (2684 lbs), alternatively at least about 2730 kg, (6034 lbs), and generally in a range of  
20 about 1220 kg to about 5000 kg, (about 2684 to about 11,013 lbs) at an inflation pressure in a range of about 723 to about 792 kpa (about 105 to about 115 psi) and having a bead diameter of at least about 48 cm (19 inches), alternatively at least about 56 cm (22  
25 inches), and generally in a range of about 48 to about 64 cm (about 19 to about 25 inches) is provided having a rubber tread of cap/base construction wherein

      (A) said tread cap is comprised of, based on 100 parts by weight rubber, (1) an elastomer composition  
30 comprised of (a) about 20 to about 70, alternatively about 30 to about 60, phr of at least one medium to high vinyl polybutadiene elastomer having a vinyl 1,2-content in a range of about 35 to about 80, alternatively about 40 to about 70, percent and (b)  
35 about 30 to about 80, alternatively about 40 to about 70, phr cis 1,4-polyisoprene natural rubber, (2) about



40 to about 85 phr, alternatively about 50 to about 80, phr of reinforcing filler comprised of (a) about 5 to about 70, alternatively about 10 to about 40, weight percent carbon black and, correspondingly, (b) about 95 to about 30, alternatively about 90 to about 60, percent precipitated silica and (c) at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers; and

(B) said tread base is comprised of, based on 100 parts by weight rubber, (1) 100 parts by weight cis 1,4-polyisoprene natural rubber, (2) about 35 to about 55, alternatively about 40 to about 50, phr of reinforcing filler comprised of (a) about 40 to about 85, alternatively about 50 to about 85, weight percent carbon black and, correspondingly, about 60 to about 15, alternatively about 50 to about 15, weight percent precipitated silica.

The said tread cap rubber and said tread base rubber may also contain about 10 to about 45, alternatively about 10 to about 30, phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, isoprene/butadiene copolymer elastomer, emulsion polymerization prepared styrene/butadiene copolymer elastomer, solution polymerization prepared styrene/butadiene copolymer elastomer and styrene/isoprene/butadiene terpolymer elastomer.

Correspondingly, with the addition of one or more of such additional elastomers to the tread cap and/or tread base and as would be understood by one having skill in the rubber compounding art, the sum of the aforesaid required basic natural rubber and medium to high vinyl polybutadiene elastomer content for the tread cap and the said basic natural rubber content for the said tread base would be represented as being





about 90 to about 55 phr, alternatively about 90 to about 70 phr for the tread cap and/or tread base.

The said tread base rubber may also contain at least one silica coupler having a silane moiety  
5 reactive with the surface of the silica and a moiety interactive with said elastomers.

In one aspect, it is considered herein that for said tread cap, the weight ratio of carbon black to silica may be in a range of about 2/1 to about 1/4.

10 The aforesaid TRA "maximum rated load limit" characteristic of the tire is intended to differentiate a truck tire typically designed for running under load conditions substantially higher than conventional passenger tire loads from passenger  
15 tires. The term "TRA" refers to "The Tire and Rim Association Inc." which is well known to those familiar with tire manufacturing. It is referred to herein as "TRA". The TRA is an association which has, as a purpose "...the establishment and promulgation of  
20 interchangeability standards for tires, rims and allied parts for the guidance of manufacturers of such products ...". The TRA publishes an annual Yearbook, for example, the 1995 Yearbook which includes, for example, characterizations of truck tires and  
25 passenger tires, including maximum rated load values at various inflation pressures. It can readily be seen that most truck tires, particularly for medium truck tires and above, have maximum rated load values at various inflation pressures significantly greater  
30 than conventional passenger tires. Therefore, it is considered herein that such values effectively differentiate the intended truck tires for this invention from conventional passenger tires. For the purposes of the description of this invention, the rim  
35 diameters referenced in the TRA Yearbook are equated to tire bead diameters. Appropriately, the tire bead



diameters are measured from the surface of the rubber encapsulated wire beads and not the wire portion of the beads, as is believed would be considered customary for such purpose.

5        It is further considered herein that the truck tires of this invention have an appreciably greater need for relatively cooler running tires than passenger tires which are expected to be utilized for substantially reduced loads. For a tire tread to  
10       contribute significantly to the cooler running of a tire, it is considered herein that a tread of cap/base construction is desirable where the tread base is primarily composed of cis 1,4-polyisoprene natural rubber and where the tread cap and tread base  
15       compositions cooperate to promote such effect. In practice, such tread is created by co-extruding the tread cap and tread base together through a singular die to form the extruded tread construction. The compounded rubber compositions are extruded through  
20       the die at a temperature in a range of about 100°C to about 125°C, typically about 110°C and, thus, is considered as being a relatively hot extrusion process, although such actual extrusion temperatures themselves are considered normal for a rubber  
25       extrusion process. The extruded tread stock is then built onto a rubber tire carcass to create an assembly thereof. The assembly is then vulcanized, or cured, at an elevated temperature. Such overall process is well known to those skilled in such art. In this  
30       manner then, by the aforesaid co-extrusion process and the covulcanization of the tread cap and tread base, the tread cap and tread base are considered herein to be an integral, c operative, unit of the tire.

35       The aforesaid tread cap and tread base, by the hot co-extrusion thereof followed by th ir co-vulcanization, ar considered to be an integral tread



- 10 -

structure, or tire component, and not a simple laminate in which two pieces of rubber are separately prepared and then cemented together or pressed together and then vulcanized.

5        Accordingly, it is considered herein that the tread cap and tread base, as an integral structure, or tire component, desirably cooperate to promote the cooler running effect for the tire. By the term  
10        cooler running for the tire tread it is meant that internal operating temperatures are sufficiently low so as to reduce, or retard, heat degradation of the tire tread rubber compositions. An example of such cooler running effect is intended to be manifested in a longer service life for the tire carcass, or casing.  
15        It is known to those having skill in truck tire usage that cooler running tire treads are desirable in order to lengthen, or increase, tire life insofar as heat durability is concerned.

20        The rubber blend for the tread cap, which is intended to be ground-contacting during use of the tire, and is required to be of a base rubber blend of said natural rubber and said medium to high vinyl polybutadiene, in combination with the primarily natural rubber based tread base. Such base rubber  
25        blend for the tread cap is considered herein to be an important feature of the invention and designed to enhance treadwear, heat buildup and rolling resistance of a tire tread containing a substantial amount of both carbon black and silica reinforcement.

30        The relatively medium to high vinyl polybutadiene for the tread cap is considered herein to be an important aspect of the invention because the relatively high vinyl content of the polybutadiene elastomer is considered to provide a greater  
35        interaction with the silica reinforcement, which is believed to be due at least in part, to the



stereochemistry of the carbon-to-carbon double bond contained in the pendant 1,2-vinyl structure contained on the elastomer polymer, particularly where the silica reinforcement is utilized in combination with  
5 the aforesaid silica coupler.

In the practice of this invention, a contribution of the polyisoprene natural rubber for the tread cap is believed to improve one or more of the tire tread's resistance to damage, the tread's traction rolling  
10 resistance and treadwear properties.

A contribution of the polyisoprene natural rubber for the tread base is intended to promote less heat buildup and, thus, a cooler running tire.

The aforesaid optional use of about 10 to about  
15 45, or about 10 to about 30, phr of at least one additional diene based elastomer in the tire tread cap is considered herein to be an additional tool to optimize tire tread properties such as, for example, tire treadwear rates.

For example, the said optional cis 1,4-  
20 polybutadiene rubber (BR), conventionally with a Tg in a range of about -85°C to about -105°C, is believed to be beneficial to enhance the tire treadwear when it is used in the tread cap. The BR used in a tread base is  
25 considered to be a cooler running elastomer than the preferred natural rubber, however, the natural rubber is typically preferred because it is considered herein that it has greater strength. The BR typically has a cis 1,4-content in a range of about 93 to about 99  
30 percent.

The use of such BR in rubber blend for grounding portions of treads such as, for example, tread cap rubber compositions, is well known to those having skill in such art.

35 A contribution of the optional trans 1,4-polybutadiene to the tread cap or tread base is





- 12 -

believed to, in one aspect, aid in increasing the stiffness property of the tire tread. In some respects, it might be considered for a partial replacement of the natural rubber.

5       A contribution of the optional emulsion polymerization prepared styrene/butadiene copolymer elastomer is believed to, on one aspect, aid in increasing a stiffness property and, for the tread cap, in enhancing tire traction property(ies) of the  
10       tire tread. A contribution of the optional solution polymerization prepared styrene/butadiene copolymer elastomer for the tread cap is believed to, one aspect, aid in enhancing tire traction property(ies) of the tire tread. In general, it is considered that  
15       such styrene/butadiene copolymer elastomers are more suitably used for the tread cap than the tread base.

      A contribution of the optional isoprene/butadiene copolymer elastomer is believed to, in one aspect, aid in improving rubber compound mixing and homogeneity of  
20       the compound ingredient dispersion which is considered herein to be a valuable contribution.

      The synthetic elastomers can be prepared, for example, by organic solution polymerization of respective monomers or, in the case of emulsion  
25       polymerization prepared styrene/butadiene copolymer elastomers by polymerization in a water medium together with appropriate emulsifiers and catalyst. Such preparation of elastomers is, in general, well known to those skilled in such art.

30       Thus, in the practice of this invention, a tire tread of a cap/base construction is provided which relies upon cooperative tread cap and tread base constructions for a truck tire tread intended to be capable of utilization under loaded conditions and  
35       designed to be relatively cool running. It is consid red herein that in a tire, the utilization for



its tire tread (i) a tread cap composed of a base blend of a relatively high vinyl polybutadiene elastomer with cis 1,4-polyisoprene natural rubber together with the silica/carbon black reinforcement which utilizes a silica coupler and, in a cooperative relationship, (ii) a tread base composed primarily of cis 1,4-polyisoprene natural rubber together with filler composed of carbon black reinforcement, which can optionally contain a minor amount of silica, is novel, particularly for a truck tire. The invention is intended to provide such a tire which has enhanced relatively cool running characteristics while also having acceptable treadwear.

The accompanying drawings are provided for further understanding of the invention, although it is not intended that the invention be limited to the presentation of the drawings. In the drawings;

FIG 1 is a cross-sectional view of a vulcanized tire showing a tread with a cap/base construction where the tread cap is of a lug and groove configuration, and where the tread base supports the tread cap and extends to the outer side surface of the tire, together with a portion of a supporting radial ply carcass. Sometimes a tire tread configuration, composed of lugs and grooves, also contains ribs which are not shown in this drawing. Such tire tread lug and groove construction, with and without ribs, are well known to those having skill in such art.

FIG 2 is a cross-sectional view of a vulcanized tire showing a tread with a cap/base construction where the tread cap is of a lug and groove configuration, together with a portion of a supporting radial ply carcass, wherein the tread base supports the tread cap and terminated within the shoulder region of the tire carcass.



- 14 -

Referring to the drawings, a tire construction 1 is provided with a circumferential tread component composed of a tread cap 2 and tread base 3 construction. The tire has a carbon black reinforced rubber carcass 4 which is composed of spaced beads 5 encased with carbon black reinforced rubber, carbon black reinforced rubber sidewalls 6 and supporting carcass plies 7 and circumferential belt 8. In one aspect the carcass plies 7 of the carcass 4, for the truck tire, has steel cord 8 reinforcement.

The rubber tread base 3 is carbon black reinforced with at least 40 phr of reinforcing filler composed of carbon black and, optionally, a minor amount of silica. The sidewall rubber 6 and rubber for the beads 5 and carcass 4 is reinforced with carbon black. The tread base elastomer is cis 1,4-polyisoprene natural rubber which contains about 30 phr of carbon black reinforcement and about 15 phr of silica. It optionally contains a silica coupler.

The rubber tread cap 2 is reinforced with about 70 phr of reinforcing filler composed of about 30 phr of carbon black and about 40 phr of precipitated silica together with a silica coupler. The tread cap rubber is composed of about 70 phr of cis 1,4-polyisoprene natural rubber and about 30 phr of a relatively high vinyl polybutadiene elastomer containing about 65 percent vinyl 1,2-units.

The siliceous pigments to be used as reinforcement in the tread cap of this invention are precipitated siliceous pigments (silica). Such precipitated silicas are prepared, for example, by controlled acidification of a soluble silicate, e.g., sodium silicate.

The siliceous pigment (silica) may, for example, have an ultimate particle size in a range of 50 to 10,000 angstroms, preferably between 50 and 400



angstroms. The BET surface area of the pigment, as measured using nitrogen gas, is preferably in the range of about 80 to about 300, perhaps even up to about 360, although more usually about 100 to about 200, square meters per gram. A BET method of measuring surface area is described in the Journal of the American Chemical Society, Volume 60, page 304 (1930).

The silica also typically has a dibutylphthalate (DBP) absorption value in a range of about 150 to about 350, and more typically about 200 to about 300.

The silica might have an average ultimate particle size, for example, in a range of about 0.01 to 0.05 micron as determined by the electron microscope, although the silica particles may be even smaller in size.

Various commercially available silicas may be considered for use in this invention such as, for example, only and without limitation, silicas commercially available from PPG Industries under the Hi-Sil trademark with designations HI-Sil 210, Hi-Sil 243, etc which might be sometimes referred to as classical silicas; silicas available from Rhone-Poulenc, such as, for example, Zeosil 1165MP, silicas available from Degussa AG with designations such as, for example, VN2, VN3, which might sometimes be referred to as classical silicas, and BV3370GR, and silicas available from J.M. Huber such as, for example, Zeopol 8745.

Mercury surface area/porosity is the specific surface area determined by mercury porosimetry. For such technique, mercury is penetrated into the pores of the sample after a thermal treatment to remove volatiles. Set up conditions may be suitably described as using a 100 mg sample; removing volatiles during 2 hours at 105°C and ambient atmospheric





pressure; ambient to 2000 bars pressure measuring range. Such evaluation may be performed according to the method described in Winslow, Shapiro in ASTM bulletin, p.39 (1959) or according to DIN 66133. For  
5 such an evaluation, a CARLO-ERBA Porosimeter 2000 might be used.

The average mercury porosity specific surface area for the silica, in general, should be in a range of about 100 to 300 m<sup>2</sup>/g and for specialized silicas  
10 for use in this invention, a range of about 150 to about 220 m<sup>2</sup>/g. It is recognized that such range overlaps and, thus, includes many classical silicas.

A suitable pore size distribution for the silica, in general, according to such mercury porosity  
15 evaluation is considered herein to be:

Five percent or less of its pores have a diameter of less than about 10 nm; 60 to 90 percent of its pores have a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores have a diameter of about  
20 100 to about 1000 nm; and 5 to 20 percent of its pores have a diameter of greater than about 1000 nm.

The physical configurations of the actual silica aggregates, which are themselves composed of pluralities of primary silica particles joined  
25 together, is important for the tread rubber composition of this invention. The physical configuration of the silica aggregate is considered to contain concave regions of various volumes which are referred to herein as macropores and sometimes  
30 referred to simply as pores and, collectively, as a measure of porosity of the silica.

The aforesaid macropores apparently capture or grasp portions of the elastomer during the mixing of elastomer and silica. It is considered herein that  
35 the containment, or capture, of a portion of the elastomer within the macropore regions of the silica



aggregate substantially enhances the reinforcing effect of the silica aggregates for the tread rubber of this invention.

5 It appears to be important that the average volume of the macropores of the silica aggregate configuration be neither too small nor too large for an optimization of this effect.

10 Thus, for the specialized silicas when used in this invention, the pore diameters, or pore diameter distribution thereof, may be measured by the aforesaid mercury porosimetry and calculated by, for example, the Washburn equation with an angle of contact that is equal to about 140 degrees and a surface tension gamma equal to about 480 dynes/cm using an instrument such  
15 as Porosimeter 2000 by Carlo Erba Instruments.

The pore size distribution for consideration in this invention is represented by an average pore diameter ratio of  $V_2/V_1$  and is considered herein to be less than 30 for classical silicas and greater than  
20 30, for example, average ratios in a range of 30 to about 70, for the specialized silicas for use in this invention. The  $V_2/V_1$  ratio is a ratio of pore volumes having a diameter between about 17.5 to about 27.5  $m^2/g$  ( $V_2$ ) to pore volumes having diameters between  
25 about 10 to about 40  $m^2/g$  ( $V_1$ ). A higher  $V_2/V_1$  value is considered herein to be more desirable, or optimal, for elastomer/silica interaction.

A  $V(Hg)$  is represented herein as the total volume of mercury which penetrates the silica, according to  
30 the aforesaid mercury porosimetry testing procedure, in terms of  $cm^3/gm$ . A representative  $V(Hg)$  for classical silicas is believed to be less than 1.7 and for specialized silicas greater than 1.7 with, for example, average values in a range of about 1.7 or  
35 1.75 to about 1.95, for silicas contemplated for use in this invention. The  $V(Hg)$  value is believed to



indicative of the overall porosity of the silica with a higher number representing a silica with a greater overall pore volume.

5 A PSD max value is a pore size maximum value represented herein as a first derivative inflection point in a curve represented as a plot of  $V(Hg)$ , (y axis), versus pore size diameter, nm, (x axis). For classical silicas, an average value is considered herein to be about 35 or greater and for specialized  
10 silicas an average value of 45 or less is believed to be representative values. It is recognized that the aforesaid ranges of values may overlap somewhat. The PSD max value is believed to be indicative of a most representative pore size of the silica aggregate.

15 Thus, it is believed herein that a definitive measure of values for a specialized silica for use in some aspects of this invention is a combination of (i) BET surface area of about 160 to about 200, (ii) an average  $V(Hg)$  value in a range of about 1.7 to about  
20 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average  $V_2/V_1$  ratio in a range of about 30 to about 65. The combination of these values is believed to be a fingerprint of suitable specialized silicas which may be used in this  
25 invention and is intended to differentiate such silicas from classical silicas.

It is readily understood by those having skill in the art that the rubber composition of the tread rubber would be compounded by methods generally known  
30 in the rubber compounding art, such as mixing the various sulfur-vulcanizable constituent rubbers with various commonly used additive materials such as, for example, curing aids, such as sulfur, activators, retarders and accelerators, processing additives, such  
35 as oils, resins including tackifying resins, silicas, and plasticizers, fillers, pigments, fatty acid, zinc



oxide, waxes, antioxidants and antiozonants, peptizing agents and reinforcing materials such as, for example, silica and carbon black. As known to those skilled in the art, depending on the intended use of the sulfur vulcanizable and sulfur vulcanized material (rubbers), the additives mentioned above are selected and commonly used in conventional amounts.

Typical additions of carbon black, silica and silica coupler for this invention are hereinbefore set forth.

Typical amounts of tackifier resins, if used, comprise about 0.5 to about 10 phr, usually about 1 to about 5 phr. Typical amounts of processing aids comprise about 1 to about 20 phr. Such processing aids can include, for example, aromatic, naphthenic, and/or paraffinic processing oils. Typical amounts of antioxidants comprise about 1 to about 5 phr.

Representative antioxidants may be, for example, diphenyl-p-phenylenediamine and others, such as, for example, those disclosed in the Vanderbilt Rubber Handbook (1978), pages 344-346. Typical amounts of antiozonants comprise about 1 to 5 phr. Typical amounts of fatty acids, if used, which can include stearic acid comprise about 0.5 to about 4 phr.

Typical amounts of zinc oxide comprise about 2 to about 5 phr. Typical amounts of waxes comprise about 1 to about 5 phr. Often microcrystalline waxes are used. Typical amounts of peptizers comprise about 0.1 to about 1 phr. Typical peptizers may be, for example, dibenzamidodiphenyl disulfide.

The vulcanization is conducted in the presence of a sulfur vulcanizing agent. Examples of suitable sulfur vulcanizing agents include elemental sulfur (free sulfur) or sulfur donating vulcanizing agents, for example, an amine disulfide, polymeric polysulfide or sulfur olefin adducts. Preferably, the sulfur





vulcanizing agent is elemental sulfur. As known to those skilled in the art, sulfur vulcanizing agents are used in an amount ranging from about 0.5 to about 4 phr, with a range of from about one to about 2.5, being preferred.

Accelerators are used to control the time and/or temperature required for vulcanization and to improve the properties of the vulcanizate. Retarders are also used to control the vulcanization rate.

In one embodiment, a single accelerator system may be used, i.e., primary accelerator. Conventionally and preferably, a primary accelerator(s) is used in total amounts ranging from about 0.5 to about 4, preferably about 0.8 to about 2.5, phr. In another embodiment, combinations of a primary or and a secondary accelerator might be used, with the secondary accelerator being used in amounts of about 0.05 to about 3 phr, for example, in order to activate and to improve the properties of the vulcanizate. Suitable types of accelerators that may be used in the present invention are amines, disulfides, guanidines, thioureas, thiazoles, thiurams, sulfenamides, dithiocarbamates and xanthates. Preferably, the primary accelerator is a sulfenamide. If a second accelerator is used, the secondary accelerator is preferably a guanidine, dithiocarbamate or thiuram compound. The presence and relative amounts of sulfur vulcanizing agent and accelerator(s) are not considered to be an aspect of this invention which is more primarily directed to the use of silica as a reinforcing filler in combination with a coupling agent in a pre-scribed rubber blend.

The presence and relative amounts of the above additives are not considered to be an aspect, except as may hereinbefore be set forth, of the present invention which is more primarily directed to the tire



with cap/base construction utilizing specified blends of elastomers in the tread cap and in the tread base, namely, primarily natural rubber and relatively high vinyl polybutadiene elastomer for the tread cap and  
5 primarily natural rubber for the tread base and with both the cap and base being reinforced with reinforcing filler composed of carbon black and precipitated silica.

The tire can be built, shaped, molded and cured  
10 by various methods which will be readily apparent to those having skill in such art.

The invention may be better understood by reference to the following examples in which the parts and percentages are by weight unless otherwise  
15 indicated.

#### EXAMPLE I

Rubber compositions (compounded rubber) were  
20 prepared of various blends of cis 1,4-polyisoprene natural rubber and relatively high vinyl polybutadiene elastomer and referred to herein as Samples A, B and C.

A control rubber composition composed of cis 1,4-  
25 polyisoprene natural rubber and cis 1,4-polybutadiene elastomer was prepared and identified herein as Sample X.

A tread base rubber composition was prepared composed of cis 1,4-polyisoprene natural rubber was  
30 prepared and identified herein as Sample Y.

The rubber compositions were prepared by mixing the ingredients in several sequential non-productive mixing stages (without the curatives) and a final productive mixing stag (basically for the curatives),  
35 then the resulting composition was cured under



- 22 -

conditions of elevated temperature and pressure,  
namely, for about 30 minutes at about 150°C.

5 The cured rubber compositions were then tested  
with various laboratory testing equipment to obtain  
physical properties of the rubber compositions which  
were then used to predict properties of a truck tire  
with a tread of a cap/base construction.

10 The rubber compositions were comprised of the  
ingredients illustrated in Table 1. The values, for  
the most part, are simply rounded to the nearest whole  
number.



Table 1					
Sample #	X	A	B	C	Y
Non-Productive Mix Stages					
Natural rubber <sup>1</sup>	50	50	70	70	100
5 Vinyl polybutadiene rubber <sup>2</sup>	0	50	30	30	0
10 Cis 1,4-polybutadiene rubber <sup>3</sup>	50	0	0	0	0
Carbon Black <sup>4</sup>	60	20	15	25	28
Processing oil, aromatic	8	8	8	8	0
Fatty Acid	2.5	2.5	2.5	2.5	1
15 Silica <sup>5</sup>	0	50	60	40	17
Plasticizers, resins and waxes	3	3	3	3	2
Coupling Agent <sup>6</sup>	0	8	9.6	6.4	3
Productive Mix Stage					
20 Zinc Oxide	3	3	3	3	9
Antioxidants <sup>7</sup>	3.5	3.5	3.5	3.5	6
Sulfur	1.2	1.2	1.2	1.2	4
25 Sulfenamide and Aniline Type Accelerators	2.5	2.5	2.5	2.5	1.2

- 1) cis 1,4-polyisoprene rubber;
- 2) polybutadiene elastomer having a vinyl 1,2-content of about 65 percent obtained from The Goodyear Tire & Rubber Company;
- 3) cis 1,4-polybutadiene elastomer having a cis content of about 96 percent and a Tg of about -104°C obtained as BUD1207 from The Goodyear Tire & Rubber Company;





- 4) added carbon black, other than carbon black contained in the silica coupler composition, as N121 obtainable from the Columbian Chemicals Company;
- 5) a silica obtained as Zeopol 8745 from the J.M. Huber Company; said silica is considered herein to be characterized by a combination of (i) BET surface area within the range 160 to 200, (ii) an average  $V(Hg)$  value within a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average  $V2/V1$  ratio in a range of about 30 to about 65.
- 6) obtained as bis-3-(triethoxysilylpropyl) tetrasulfide (50% active) commercially available as X50S from Degussa as a 50/50 blend of the tetrasulfide with N330 carbon black (thus, considered 50% active); technically, the tetrasulfide is believed to be an organosilane polysulfide as a composite, or mixture, having an average number of sulfur atoms in a polysulfide bridge in a range of about 3.5 to about 4 connecting sulfur atoms, although the composite, or mixture may contain individual organosilane polysulfides with about 2 to about 8 connecting sulfur atoms; and
- 7) of the diarylparaphenylene diamine and dihydro-trimethylquinoline type.



Various properties of the cured samples were determined by conventional means and reported in the following Table 2.

Table 2					
Sample #	X	A	B	C	Y
300% Modulus (Mpa)	11.09	15.24	17.3	15.72	11.15
Tensile Strength (MPa)	18.45	15.35	17.33	17.10	17.94
Elongation (%)	480	325	313	311	468
Hardness	66	68.1	73.1	70.6	57.3
Rebound (100 °C)	57.1	64.4	63.4	67.7	76.0
Flexometer Temperature (°C)	29.1	21.1	20.8	16.7	8.3
Percent Set	2.44	1.45	1.8	1.25	0.59
E' at 0°C (MPa)	32.9	31.5	42.5	24.7	26.7
E' at 60°C (MPa)	19.7	20.0	26.5	17.5	11.7
Tan. Delta at 0°C	.087	.112	.098	.104	.121
Tan. Delta at 60°C	.091	.073	.062	.057	.056

For the tensile elongation and 300% modulus values tests, refer to ASTM Test D412-92, method B.

For the rebound tests, refer to DIN 53512.

For the hardness, Shore A as in ASTM 2240-91 may be referred to as determined at room temperature, or about 23°C.

For the flexometer test refer to ASTM Test D623. The flexometer test is considered herein to be significant because it specifically measures the temperature rise in the rubber test sample and the dimensional changes of the sample over time. The flexometer test is well known to those skilled in rubber composition evaluations particularly for use in tires.



For the  $E'$  values, which are sometimes referred to as the tensile storage modulus, reference may be made to Science and Technology of Rubber, second edition, 1994, Academic Press, San Diego, CA, edited by James E. Mark et al, pages 249-254. The use of the storage modulus,  $E'$ , to characterize rubber compositions is well known to those having skill in such art.

The tangent delta, or tan. delta, is a ratio of the tensile loss modulus, also known as  $E''$ , to the tensile storage modulus ( $E'$ ). These properties, namely the  $E'$ ,  $E''$  and tan. delta, characterize the viscoelastic response of a rubber test sample to a tensile deformation at a fixed frequency and temperature, most often measured at 0°C and 60°C.

The tan. delta and tensile storage modulus ( $E'$ ) are well known to those skilled in the rubber composition characterization art, particularly as relates to tires and tire treads. The tensile storage modulus ( $E'$ ) values are indicative of rubber compound stiffness which can relate to treadwear rates and evenness of treadwear. The tan. delta value at 60 or 0°C is considered as being indicative of hysteresis, or heat loss. Additionally, the tan. delta value at 0°C has been empirically correlated to tire tread skid properties and is well known in the art as a predictor of tire tread traction, or skid, properties.

In particular, the lower flexometer temperature rise values shown for Samples A, B, and C versus the higher flexometer temperature value shown for Control Sample X illustrate that the tire tread cap compositions made of either of the rubber compositions presented by Samples A, B or C would build up less heat under tire operating conditions than a tread cap of a rubber composition represented by Control Sample X and, thus, provide a cooler running tire tread,



particularly when coupled, or combined, with the tread base Y to form a tire tread, which in comparison to Control Sample X, builds up very little heat in the flexometer testing.

5        Indeed, it is considered herein to be significant that the tire tread cap composition candidates, represented by Samples A, B and C are composed of natural rubber and a relatively high vinyl  
10       combination of carbon black and silica together with a silica coupler.

      Accordingly, it is considered herein that rubber composition properties of the tire tread cap rubber compositions A, B and C taken together with tire base  
15       composition Y, particularly when compared with comparative control tire cap composition X, are predictive that a cap/base tread construction of this invention will provide a tire with enhanced (i)  
20       traction as evidenced by the tan. delta values at 0°C and rolling resistance as evidenced by rebound values at 100°C and tan. delta values at 60°C, (ii) tread with a cooler internal running temperature as evidenced by the flexometer temperature values; and  
25       (iii) acceptable treadwear as evidenced by a combination of 300 percent modulus, tensile strength and storage modulus (E') at 0°C and at 60°C.

      Indeed it is considered herein that the cooperative combination of the outer tread cap and underlying tread base provides the following benefit:  
30       promotion of a cooler internal running temperature for the overall tread under operating conditions, namely running under load, which is predictively evidenced by the flexometer temperature values. This is considered as being beneficial to truck tire users by promoting a  
35       longer lasting, due to the cooler running tread





concept, and acceptable treadwear tire with potential fuel economy.

5 In practice, in the manufacture of tires, their individual rim size is conventionally incorporated into tire size terminology by being molded into the sidewall of the tire. Such terminology may read, for example, as 11R24.5, 295/75R22.5, 285/75R24.5, or 11R22.5. For example, an inscription of 11R24.5 would mean a radial ply tire having a width of 11 inches,  
10 and a rim diameter of 24.5 inches.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and  
15 modifications may be made therein without departing from the spirit or scope of the invention.



- 29 -

WHAT IS CLAIMED IS:

The claims defining the invention are as follows:

1. A pneumatic tire having a TRA rated load limit of at least about 1220 kg at an inflation pressure in a range of about 723 to about 792 kpa and having a bead diameter of at least about 48 cm is provided having a rubber tread of cap/base construction wherein

(A) said tread cap is comprised of, based on 100 parts by weight rubber, (1) an elastomer composition comprised of (a) about 20 to about 70 phr of at least one medium to high vinyl polybutadiene elastomer having a vinyl 1,2-content in a range of about 35 to about 80 percent and (b) about 30 to about 80 phr cis 1,4-polyisoprene natural rubber, (2) about 40 to about 85 phr of reinforcing filler comprised of (a) about 5 to about 70 weight percent carbon black and, correspondingly, (b) about 95 to about 30 percent precipitated silica and (c) at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers; and

(B) said tread base is comprised of, based on 100 parts by weight rubber, (1) 100 parts by weight cis 1,4-polyisoprene natural rubber, (2) about 35 to about 55 phr of reinforcing filler comprised of (a) about 40 to about 85 weight percent carbon black and, correspondingly, about 60 to about 15 weight percent precipitated silica.

2. The tire of claim 1 where said silica is characterized by having a BET surface area in a range of about 100 to about 360 and a DBP absorption value in a range of about 200 to about 400.



3. The tire of claim 1 where, for said tread cap, the weight ratio of carbon black to silica is in a range of about 2/1 to about 1/4.

5 4. The tire of claim 1 where, for said tread cap, the said coupler is a bis-3-(trialkoxysilylalkyl) polysulfide having a polysulfide bridge containing from 2 to about 8 connecting sulfur atoms.

10 5. The tire of claim 1 where, for said tread cap, the said coupler is composed of bis-3-(triethoxysilylpropyl)tetrasulfide.

15 6. The tire of claim 1 where, for said tread cap, said silica is characterized by a combination of (i) BET surface area of about 160 to about 200, (ii) an average V(Hg) value in a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average V2/V1 ratio  
20 in a range of about 30 to about 65.

7. The tire of claim 1 having a TRA rated load limit in a range of about 1220 kg to about 5000 kg, at an inflation pressure in a range of about 723 to about  
25 792 kpa and a bead diameter in a range of about 48 to about 64 cm.

8. The pneumatic tire of claim 1 having a TRA rated load limit of at least about 2730 kg, at an  
30 inflation pressure in a range of about 723 to about 792 kpa and having a bead diameter of at least about 56 cm is provided having a rubber tread of an integral cap/base construction wherein

(A) said tread cap is comprised of, based on 100  
35 parts by weight rubber, (1) an elastomer composition comprised of (a) about 30 to about 60, phr of medium



to high vinyl polybutadiene elastomer having a vinyl  
1,2-content in a range of about 40 to about 70,  
percent and (b) about 40 to about 70, phr cis 1,4-  
polyisoprene natural rubber, (2) about 50 to about 80  
5 phr of reinforcing filler comprised of (a) about 5 to  
about 40, weight percent carbon black and,  
correspondingly, (b) about 95 to about 60, percent  
precipitated silica and (c) at least one silica  
coupler having a silane moiety reactive with the  
10 surface of the silica and a moiety interactive with  
said elastomers; and

(B) said tread base is comprised of, based on 100  
parts by weight rubber, (1) 100 parts by weight cis  
1,4-polyisoprene natural rubber, (2) about 35 to about  
15 50 phr of reinforcing filler comprised of (a) about 50  
to about 85 weight percent carbon black and,  
correspondingly, about 50 to about 15 weight percent  
precipitated silica.

20 9. The tire of claim 1 wherein said tread cap  
also contains about 10 to about 45 phr of at least one  
additional diene based elastomer selected from cis  
1,4-polybutadiene elastomer, trans 1,4-polybutadiene  
elastomer, isoprene/butadiene copolymer elastomer,  
25 emulsion polymerization prepared styrene/butadiene  
copolymer elastomer, solution polymerization prepared  
styrene/butadiene copolymer elastomer and  
styrene/isoprene/butadiene terpolymer elastomer; and  
wherein said silica is characterized by a combination  
30 of (i) BET surface area of about 160 to about 200,  
(ii) an average V(Hg) value in a range of about 1.7 to  
about 1.95, (iii) an average PSD max in a range of  
about 10 to about 45 and (iv) an average V2/V1 ratio  
in a range of about 30 to about 65.





10. The tire of claim 1 wherein said tread base also contains about 10 to about 30 phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, and isoprene/butadiene copolymer elastomer.

11. The tire of claim 8 wherein said tread cap also contains about 10 to about 30 phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, isoprene/butadiene copolymer elastomer, and emulsion polymerization prepared styrene/butadiene copolymer elastomer; and wherein said silica is characterized by a combination of (i) BET surface area of about 160 to about 200, (ii) an average V(Hg) value in a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average V2/V1 ratio in a range of about 30 to about 65.

12. The tire of claim 8 wherein said tread base also contains about 10 to about 30 phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, and isoprene/butadiene copolymer elastomer and where said tread base also contains at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers; and wherein said silica is characterized by a combination of (i) BET surface area of about 160 to about 200, (ii) an average V(Hg) value in a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average V2/V1 ratio in a range of about 30 to about 65.



13. The tire of claim 1 wherein said tread base also contains at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers.

5

14. The tire of claim 8 wherein said tread base also contains at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers.

10

15. The tire of claim 9 wherein said tread base also contains at least one silica coupler having a silane moiety reactive with the surface of the silica and a moiety interactive with said elastomers.

15

16. The tire of claim 13 where said coupler is a bis-3-(trialkoxysilylalkyl) polysulfide having a polysulfide bridge containing from 2 to about 8 connecting sulfur atoms.

20

17. The tire of claim 8 where, for said tread cap, said silica is characterized by a combination of (i) BET surface area of about 160 to about 200, (ii) an average V(Hg) value in a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average V2/V1 ratio in a range of about 30 to about 65.

25

18. The tire of claim 8 wherein said tread cap also contains about 10 to about 45 phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, isoprene/butadiene copolymer elastomer, and emulsion polymerization prepared styrene/butadiene copolymer elastomer; wherein said silica for said cap is characterized by a combination of (i) BET surface

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area of about 160 to about 200, (ii) an average V(Hg) value in a range of about 1.7 to about 1.95, (iii) an average PSD max in a range of about 10 to about 45 and (iv) an average V2/V1 ratio in a range of about 30 to about 65; wherein said coupler for said silica in said tread cap is a bis-3-(trialkoxysilylalkyl) polysulfide having a polysulfide bridge containing from 2 to about 8 connecting sulfur atoms; and wherein said tread base also contains about 10 to about 30 phr of at least one additional diene based elastomer selected from cis 1,4-polybutadiene elastomer, trans 1,4-polybutadiene elastomer, and isoprene/butadiene copolymer elastomer.

19. A pneumatic tire, substantially as hereinbefore described with reference to any one of the Examples but excluding the Comparative Examples.

**Dated 17 April, 1996**  
**The Goodyear Tire & Rubber Company**

**Patent Attorneys for the Applicant/Nominated Person**  
**SPRUSON & FERGUSON**



## Tire with Tread of Cap/Base Construction

### Abstract

The invention relates to a tire with a rubber tread of a cap/base construction wherein  
5 the tread base is composed of carbon black and silica reinforced natural rubber and the  
tread cap is composed of a blend of elastomers which is reinforced with carbon black and  
silica.

The invention particularly relates to truck tires.

The tire of the invention has a TRA rated load limit of at least about 1220 kg at an  
10 inflation pressure in a range of about 723 to about 792 kpa and having a bead diameter of  
at least about 48 cm is provided having a rubber tread of cap/base construction wherein

(A) said tread cap is comprised of, based on 100 parts by weight rubber, (1) an  
elastomer composition comprised of (a) about 20 to about 70 phr of at least one medium  
to high vinyl polybutadiene elastomer having a vinyl 1,2-content in a range of about 35 to  
15 about 80 percent and (b) about 30 to about 80 phr cis 1,4-polyisoprene natural rubber, (2)  
about 40 to about 85 phr of reinforcing filler comprised of (a) about 5 to about 70 weight  
percent carbon black and, correspondingly, (b) about 95 to about 30 percent precipitated  
silica and (c) at least one silica coupler having a silane moiety reactive with the surface of  
the silica and a moiety interactive with said elastomers; and

20 (B) said tread base is comprised of, based on 100 parts by weight rubber, (1) 100  
parts by weight cis 1,4-polyisoprene natural rubber, (2) about 35 to about 55 phr of  
reinforcing filler comprised of (a) about 40 to about 85 weight percent carbon black and,  
correspondingly, about 60 to about 15 weight percent precipitated silica.





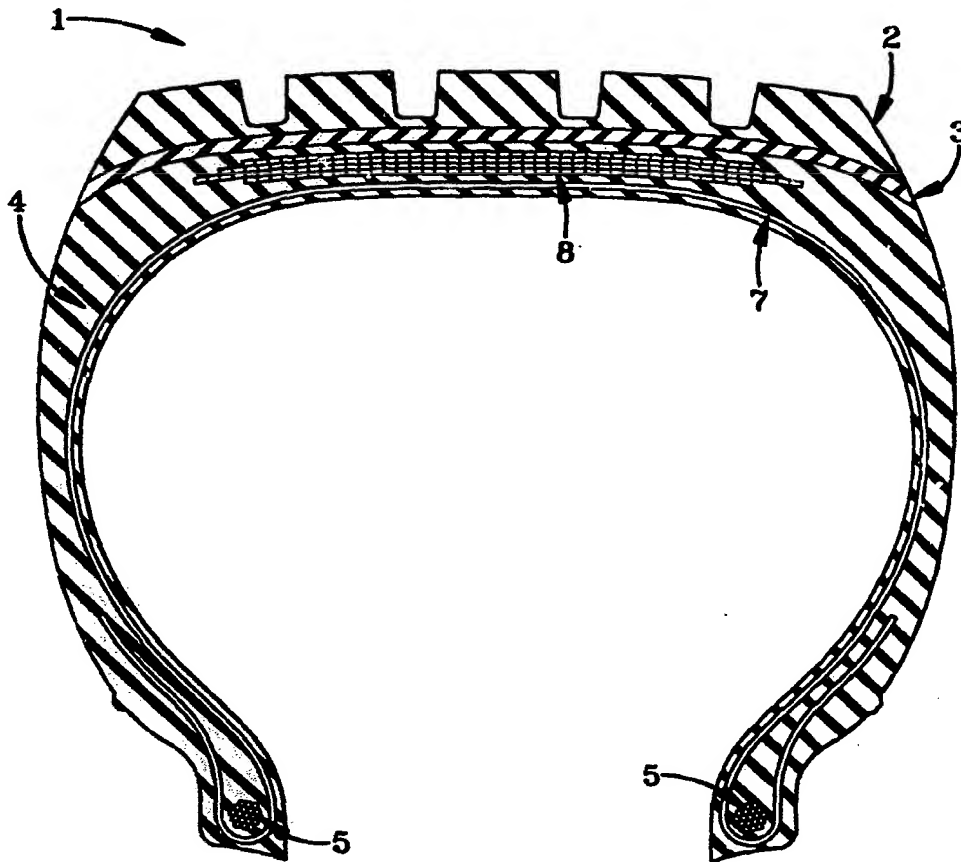


FIG-1

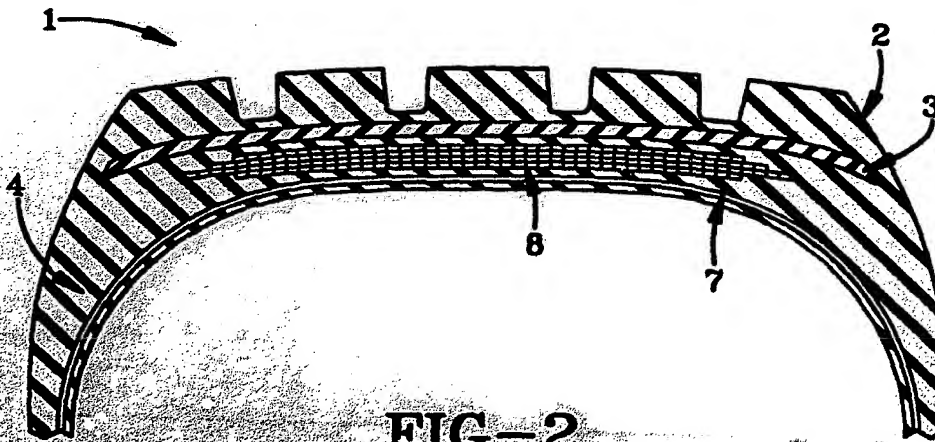


FIG-2

